

**DEMONSTRATION OF MAGNETIC DOMAIN
BOUNDARY MOVEMENT USING AN EASILY
ASSEMBLED VIDEOCAM-MICROSCOPE SYSTEM**

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KEY WORDS: magnetic domains, domain boundary migration, videocam microscope.

PREREQUISITE KNOWLEDGE: Familiarity with the proper care and use of ordinary video equipment and such optical lenses as are found on video cameras and standard optical microscopes. The main concern here is to prevent damage to the microscope objective lens, the videocam, and to the connectors for the video camera, the tv monitor or the vcr equipment used in this demonstration.

OBJECTIVES To build and demonstrate a low cost and highly flexible tv microscope facility and then use it to view the motion of magnetic domain boundaries as the local magnetic field is varied. The expense of an optical microscope and the videocam adapters sold for them is largely avoided by using the facility described below.

EQUIPMENT AND SUPPLIES

1. An inexpensive home video camera with a manually operated zoom capability. The type used by most athletic departments for making game and scrimmage tapes should do fine. In many high schools, colleges and universities, videocams are available on a checkout basis from a media resources department.
2. A 10-power, 0.25 numerical aperture objective lens such as can be found on the optical microscopes in biology or metallographic preparation labs. However, new ones can be purchased from optical dealers such as Bausch and Lomb, Edmund's Scientific and others for about \$35 to \$50.
3. A 1 mm x 1 mm x 0.1 mm sample of magnetic bubble material (ferrimagnetic garnet "FMG" crystal) such as can be found in the 1991 Cenco or TEL-Atomic science supplies catalog for around \$145.00. The specimen comes already mounted at the center of a brass disk for ease of handling. It is also convenient for attaching it to the end of a mailing-tube holder as described below.
4. A small, adjustable beam flashlight (commonly called a mag-lite) for illuminating the sample from behind. This item can be purchased for a few dollars in most hardware and discount stores.
5. A mailing-tube such as the plastic ones used to package the disposable 40cc syringes used by livestock veterinarians. Vets view these as throwaway packaging materials, which makes it easy to obtain free supply.

PROCEDURE: The procedure for setting up this simple but effective tv microscope facility has been demonstrated nicely in an informal videotape produced by Dr. Dale Stille, at the University of Iowa, who originated the idea. The procedure outlined here was taken from Stille's videotape. He uses an optical bench to reduce vibration and ease positioning, but it is not essential. Kindly refer to Figure 1.

1. Mount the video camera on a suitable tripod, turn it on, advance the zoom setting to its maximum, and place it on the lab or lecture bench with the line of sight horizontal and about chest high.
2. Affix the brass specimen holder to the end of the throwaway plastic tube and position this so that the specimen is about a foot or so from the videocam and directly in the line of sight. Of course the axis of the tube should be colinear with the line of sight of the videocam.
3. Now mount the microscope objective lens on an appropriate stand and interpose it between the videocam lens and the specimen. Make sure its axis is colinear with the other two and that the threaded end of the objective is just brushing the lens of the videocam. Don't worry about the light that may enter the videocam lens without going through the objective. Attempts to block it, as with a bellows or similar arrangement, will likely do more harm than good. The image quality without bellows is very good.
4. Switch on the mag-lite and lay it inside the specimen-holder tube so that it shines on the back of the brass specimen-holder and through the tiny FMG crystal.
5. Now, gently move the specimen-holder tube toward the video camera until the specimen virtually touches the lens of the microscope objective. Be careful here; the objective is grazing the videocam lens to the rear while its own lens is within 1.0 mm or so of the FMG crystal specimen, so there is danger of damaging a lens.
6. Everything is now ready. Peer through the viewfinder of the videocam and back off on the zoom to bring the specimen into sharp focus-- manual focus of the videocam may also help. The tiny specimen should be well illuminated and should fill the entire field of view (and tv screen).
7. To induce domain boundary migration, bring the north or south pole of a permanent magnet close to the specimen and watch what happens. You will soon discover how to achieve the best effects for your purposes.
8. At this point you can tape a lecture demonstration for a later showing, or you can connect the videocam directly to a tv monitor and show the effects in real time as you describe what's going on.

NOTES TO THE INSTRUCTOR

A wide variety of quantitative experiments and demonstrations can be performed using the apparatus described above. The emphasis here, however, is more on the facility itself than on the experiments made possible once it is assembled.

It should be noted, however, that the TEL-Atomics FMG crystals come with a coil located in the brass mount. When connected to a dry-cell or a 0-6v dc power supply, one can vary the coil current and hence the magnetizing field strength, H , in a controlled fashion. The number of non-oriented domains decreases with H , as can be observed on the tv screen, and at saturation only a single domain will be seen and it will be oriented with H . To plot magnetization M vs H curves, hysteresis loops and the like, a way must be found to monitor and plot M . The references by Tanner^{1, 2} and Nielson³ should prove helpful in this regard.

Specimens demonstrating other physical phenomena can be used in place of the FMG crystal. Brownian motion cells and liquid crystal specimens are two that come to mind but I am certain many readers will think up several of their own. A most intriguing-- but not yet tested-- possibility is to use observations on liquid crystal specimens to simulate "phase transitions" in polymeric materials and even in the early stages of cosmology. For a recent article on the cosmology angle, see the reference by Ivars Peterson⁴.

One final note. Some instructors prepare several holder-tubes, each with its own specimen and microscope objective already fixed in the proper positions inside. Each can be mounted as a self-contained unit, which saves alignment and adjustment time before each demonstration, but this means objective lenses remain tied up.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge Dale Stille (rhymes with Billy), who is the Lecture Demonstration Coordinator for the Physics Department of the University of Iowa in Iowa City, Iowa 52242. Dale originated the procedures described above and kindly provided many helpful comments during preparation of this manuscript. Mr. Erv Poduska of Kirkwood Community College presented Stille's videotaped demonstration at the Spring 1991 meeting of the Iowa Academy of Science, which is what piqued my interest.

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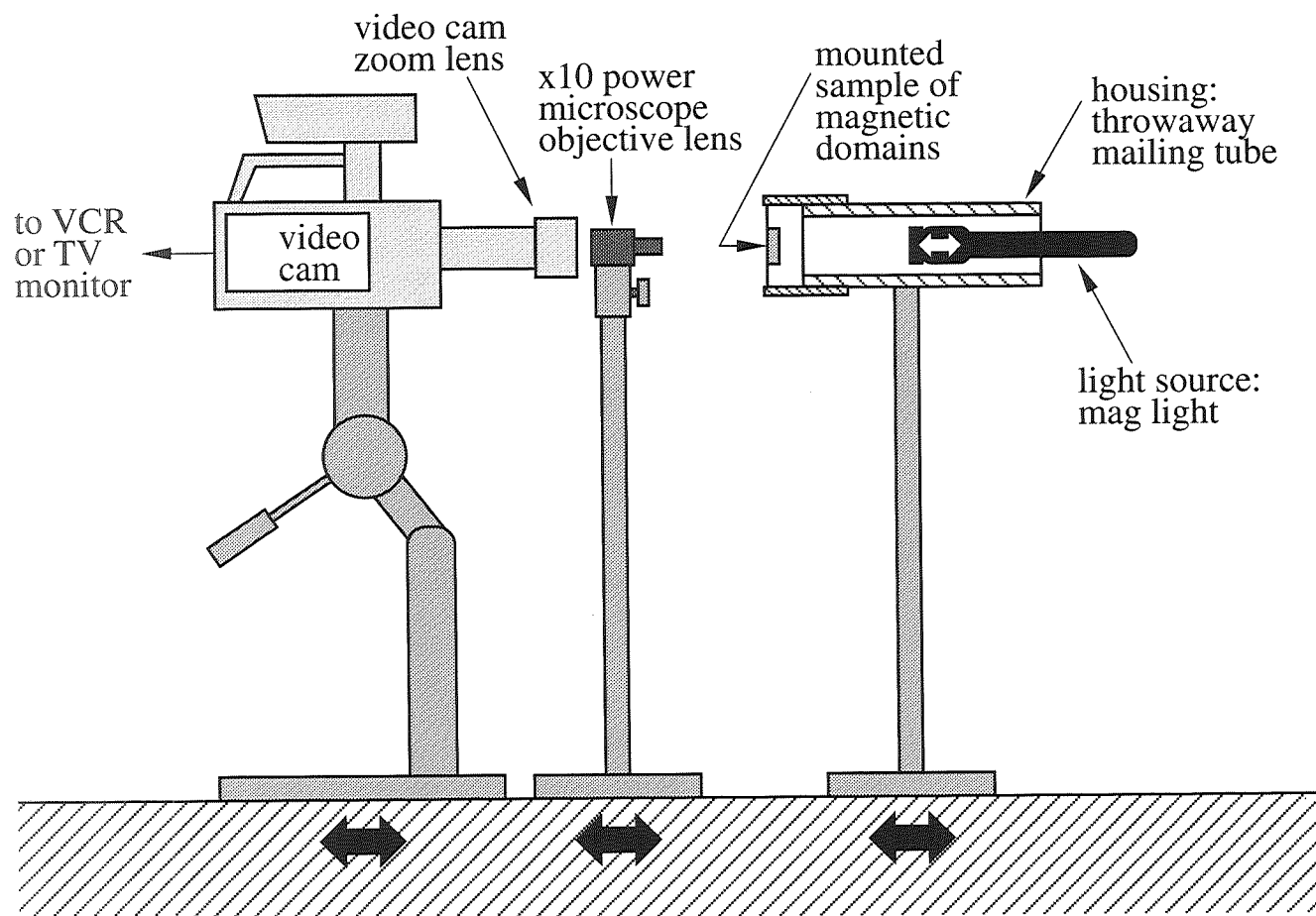


Figure 1